THE STINGLESS BEES OF AUSTRALIA.

By TARLTON RAYMENT.

2. THE ARCHITECTURE.

All of the Australian species known to me build in hollows in trees. As botanists are well aware, the growth of *Eucalyptus* trees takes place in the outer layers of the bole, and the interior is often a long, irregular, tube-like cavity encompassed by dark-brown decayed wood which, shrinking as it dries, falls to the base of the tree. The result of the decomposition is an uneven tube, the sides of which are formed of dark, thin shells of old timber. Branches decay and fall off, and the scars make openings to the interior, which is then available to swarms seeking a new home. Cracks, due to various causes, also provide a means of ingress and egress.

The introduced honey-bee, *Apis*, is not one whit behind the *Trigona* in establishing itself in such propitious quarters, though *Apis* demands a much larger cavity. Both genera proceed to render the home waterproof and clean, by covering the whole of the interior with a coating of dark resinous material which is singularly resistant to water, soaps and acids.

Many of the *Trigona* build on the outside of the entrance a porch, of a like resinous material. It is shaped like a slightly-bent human index finger: others construct an ill-shaped excrescence, containing several by-ways through which the bees pass. These latter kind may be a development of the resin-ball nidus constructed by the *Anthidium* of Europe, while the former finger-like cylindrical projection probably has its origin in the mud porches of the *Anthophora*.

The European *Anthophora pilipes* excavates in sunny banks, but instead of casting the "spoil" away, she builds a tube-like projection with the earth. The finished material resembles the "rough-cast" work of the fairy-martin in miniature. As the bee requires her interior cell-partitions, she gradually removes the necessary material from her porch, and when her nest is completed, the entire projection has been utilised in this economical manner. The funnel-like porch of *Trigona* is sometimes four cm. in height, and often is constructed of resin from the turpentine tree, *Syncarpia*.

T. cassiae constructs a "covered way" from the interior of the entrance, and some that I investigated had a waxy structure straight for ten cm. in length; it then turned up, at a right angle, for a further three cm. The diameter of the interior of the tube measured one cm.; the thickness of the material being almost two mm. Where the entrance of my box-hive was at a median position on the bottom, the tube was built along the interior of the angle;

the wax being laid down on the wood of the floor, but on the vertical wall of the front, apart from the film coating the entire interior, the wax is limited to a raised longitudinal median line.

It seems that the insects must build from a transverse position and, after filling up the angle, continue the curve of the bottom of the tube, but thinning out the material on the wood. When the roof is constructed the same rule applies, and the two curves meeting result in the raised line. The structural materials of *T. cassiae*

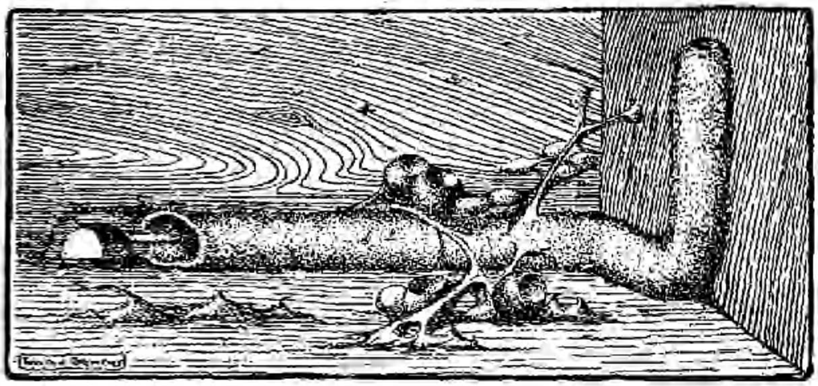

Fig. 1.

The Covered Way.

The workers of *T. cassiae* construct a covered way from the interior of the hive-entrance to a point nearer the centre of the brood-nest. (The gallery is torn away from the entrance to show a graphic section of it.)

are decidedly paler in colour, more plastic, and not nearly so resinous as those of *T. carbonaria*, consequently, the workmanship of the former is of a higher order; the cells, too, are of thinner construction.

Both the hive- and the stingless-bees use two substances for building, viz., wax and a resinous material—termed propolis by the ancient Greeks, who observed the wax curtains, often pendant over the portal of the hive, to reduce the size of the aperture.

The beautifully regular waxen structure of the hive-bee, *Apis*, has one septum composed of rhombs, three of which form the base of each cell. Since the septum and the hexagonal cell-walls on each side are integral portions of the comb, the centres of the bases of all cells on one side are interstitial with the junctions of the cell-walls of the opposite side. Darwin, in two pages of text, endeavoured to prove that the hexagons were really the result of "mutual pressure" applied to a number of cylinders.

A simple experiment demonstrated the futility of his contention. I placed in colonies of hive-bees, hundreds of hexagonal cells, and after fifty hours the bees had rebuilt them into hundreds of cylindrical cells. I then gave the same colony many hundreds of small cylindrical cell-bases, and after twenty-four hours, the bees had transformed the round cells into the regular hexagonal form. When the building conditions are favourable, the result is always the same. The bees require a few typical cylindrical cells for nurturing perfect females, but prefer hexagonal cells for the numerous undeveloped females or worker-bees.

The queen-cradle of the hive-bee, then, is the typical form of all bees' cells. The silver purse of the primitive *Euryglossa*, and the rude earthen chamber of *Halictus*, both conform to the elemental pattern, but *Trigona* is experimenting in the use of the rhomb.

T. carbonaria are, numerically, the strongest colonies, and their architecture is remarkable for the excessive use of struts and toms. These peripheral supporting structures are often a veritable maze of interlaced "strings," attached to the sides of a cavity, which is generally in the rotten "pipe" of a tree. On this surprisingly firm framework, the large honey-storage cells are built in curious disorder. Where two cells are contiguous, one integral wall serves for the division, and here are the elements of the highly efficient rhomboid structure of the hive-bee.

These large, misshapen cells are halfway between cylinders and hexagons, but the true contours are partially buried in the compact waxy mass. Strange to say, the hive-bee exhibits this trait when it attempts to surround the queen-cells with honeycomb, a natural propensity not at all relished by the professional breeder of queen-bees.

The storage cells are vertical, measuring 9 mm. in diameter, and have a capacity of 75 c. mm.; the thin lip being extended up as the cell is filled. The hive-bee builds up the lower lip of its horizontal cell for a similar purpose. The storage cells of *T. cassiae* are of a lighter-coloured, finer quality wax, and, as one would expect, the structure is superior. The honey-cells are loosely attached, but each is a perfectly formed sub-spherical "basin," equalling in beauty the vessel of the common cup-moth. This species has only a few struts; the cells frequently adhering to the hive-wall; some of these, when viewed by transmitted light, reveal the elements of the rhombs.

The pollen is stored in similar containers, and when sealed cannot be distinguished until the cell is broken. Microscopical examination shows the stored pollen to be a mixture from many widely divergent botanical species, including *Eucalyptus, Hardenbergia, Cassia, Angophora, Xanthorrhoea, Helianthus, Cryptostemma,* and many other plants. This comprehensive diet is comparable with that of the hive-bee, but it is in strong contrast to the restricted range of *Trichocolletes*, which confines itself to *Daviesia* species. The pollen is of a moist, mealy constituency, and contains the small percentage of honey that characterises the stored mixed pollen of the hive-bee, which, however, does not usually seal over the pollen-cells.

Each cylindrical brood-cell of *T. cassiae* is a separate entity, and though there is often a very thin septum between the groups of cells, yet each cell can easily be detached without injury to the contiguous ones. Moreover, the attachment is very frail, and the cells are often at all kinds of angles.

It has been observed that the "tube-porch" of *Trigona* is frequently contracted, and sometimes entirely closed with resinous pellets, but this reduction of the portal is also a feature of the hive-bees' labour, and thin sheets of this material were responsible for the Greeks' name.

It has been suggested that the propolis barriers are an additional defence against insect enemies, such as ants, wasps, beetles and flies, but I desire to stress the fact that numerous inquilines are found in the hive-interior. The barriers are built for the sole purpose of securing a greater control over the temperature of the interior, the honey-bee being extremely assiduous at this labour as winter approaches.

Like all bees, *Trigona* has a "horror" of anything movable about the interior of the hive, and it promptly secures all loose objects with a few struts or strands of resin. That the door-barriers are for controlling the conditions of the brood-nest is proved, I think, by the fact that colonies packed for travel, and provided with wire-screen ventilators, will at once proceed to "plaster up" the extra "air-ports" to nullify the observer's intention. Bates stated that mud is mixed with the wax of some American species.

Under the microscope the exterior of the curtain on the wire shews that small pellets have been just thrust through the interstices without order; a careless tipping-in of mere "filling" composed of a debris of vegetable red kino, from the tree itself, scraps of resin and fragments of wax. This careless workmanship is exactly duplicated by the hive-bee, when "filling in" the interstices between the circular caps covering the honey-cells. The interior is much smoother, having been "trowelled" by the mandibles of the workers. The *Trigona* excells the hive-bee in its rapid closing with propolis all superfluous cracks and crevices, other than the recognised doorway. In three hours, a *Trigona* colony closed an aperture 12 cm. long by 2 cm. wide. The pellets are carried in the mandibles, and each pellet equals in volume the head of a small pin. Both stingless- and hive-bees use the propolis over and over again, especially when the old and previously discarded material has been re-softened by the warmth of the sun.

The bees, both hive- and stingless, have the ability to reduce the vegetable resin to a thin liquid that can be used as a yellowish varnish of great durability. Though I have not been able to determine how this is effected, yet I have no doubt that the viscid liquid is "brushed" on by the glossa. The coating is extremely tenuous, and shows no "trowelling" by the mandibles. Indeed, the new creamy-white honey-comb of the hive-bee later receives a delicate covering of a like yellow varnish.

In among the masses of honey-cells and wax-struts, I have observed a number of small "pop-holes," or alley-ways, affording a "short cut" to the other side of the combs. There is not the

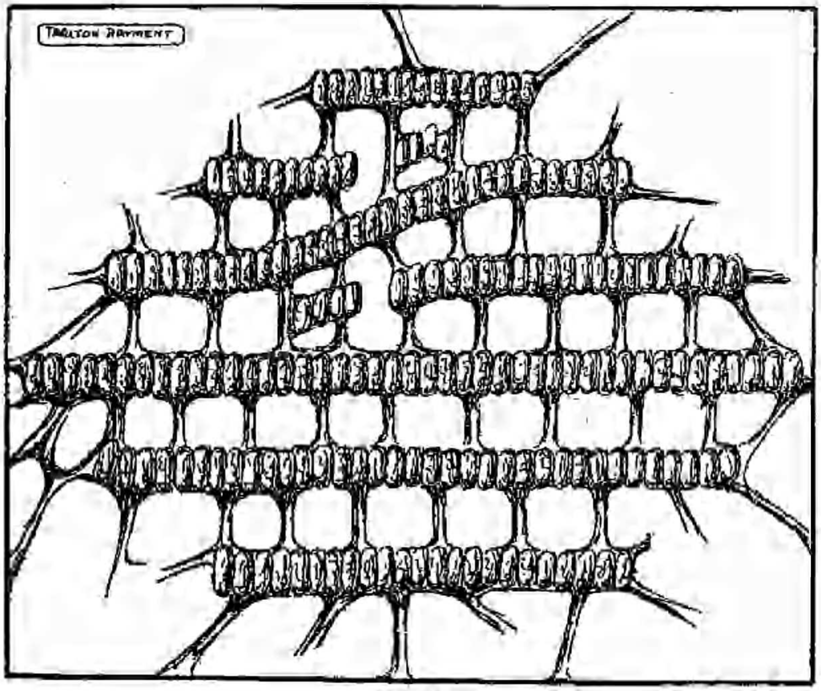

Fig. 2.

A section through the "brood-nest" of *T. carbonaria* reveals a spherical form, suggesting the arrangement of the British wasp, *Vespa vulgaris*. Here are the elements of the spherical cluster of the hive-bee. Note the deflection of the upper combs, a deviation common to the structures of the hive-bee.

slightest doubt that these passages are time-saving highways obviating the necessity for crawling over a large mass to reach the antipodes. They are in every way comparable to the unsightly, but eminently convenient, "pop-holes" in the corners of the honey-combs produced in modern apiaries. The trait will never be eliminated, but the commercial apiarist may modify the demand for "short-cut-alleys" by making the interior furniture of the bee-hive conform more closely to the requirements of the insects.

To prove that the honey-cups of *Trigona*, and the incipient queen-cells of the hive-bee, are of typical form, I have transposed larvae of the latter to cell-cups of the former, and the hive-bees readily accepted, and completed, the building of them into normal queen-cradles. The wax cups, though shaped like the initial honey-vessel of the queen *Bremus* (*Bombus*), are of more delicate modelling.

A close study of the interior walls of the hives of *Trigona* reveals many efforts to experiment with hexagons, and since these angular foundations are usually very large, and traced out directly on the flat wood, the "mutual pressure" theory cannot apply. The walls of almost any colony of hive-bees will reveal similar hexagonal tracings in wax. I was interested, too, on finding among the waxy framework, many evidences of hexagonal structure, and the drawing was made from an actual piece of comb from a colony of *T. cassiae*.

For purposes of comparison I have obtained accounts of *Trigona* nests from observers in many other countries, but a few South African reports—hitherto unpublished—will serve to reveal the striking similarity to the biology of the Australian species.

The oval queen-cell of *T. cassiae* is considerably larger than the worker-cells, being 7 mm. at its long axis, and 4·5 at its short axis. It is, too, reinforced with a number of ribs; undoubtedly, these are the elements of the elaborate hexagonal reinforcement of the queen-cell of *Apis*. There is also a further likeness in the apex of the cell being reduced in thickness; the wax being removed until the cocoon itself is visible. The queen-cell of *Apis* being inverted, the bottom is the place of exit, and the cell is thinnest there. In addition to the wax ribs, the thin wall of the cells receives a number of circular "dabs" of dark propolis in irregular order.

At one time it was contended that the mere inverting of the pregnant queen-cells of *Apis* was sufficient to kill the young queens, a catastrophe that retarded the issuing of swarms, and so gave the apiarist a more efficient control over his colonies. Indeed, a certain type of hive was patented to permit inversion of the entire combs in one operation. I have been able to demonstrate that any rude shock during the process would most certainly destroy the females, but the mere turning of them upside down did not have any harmful result. Queen-cells of *Apis* and *Trigona* were placed at all angles, and queens of normal development emerged in proper sequence. The pendent inverted position of the queen-cells of *Apis* is probably an inherited character, for all the worker-cells of *T. carbonaria* are mouth down. On the other hand, *T. cassiae* builds them at any angle.

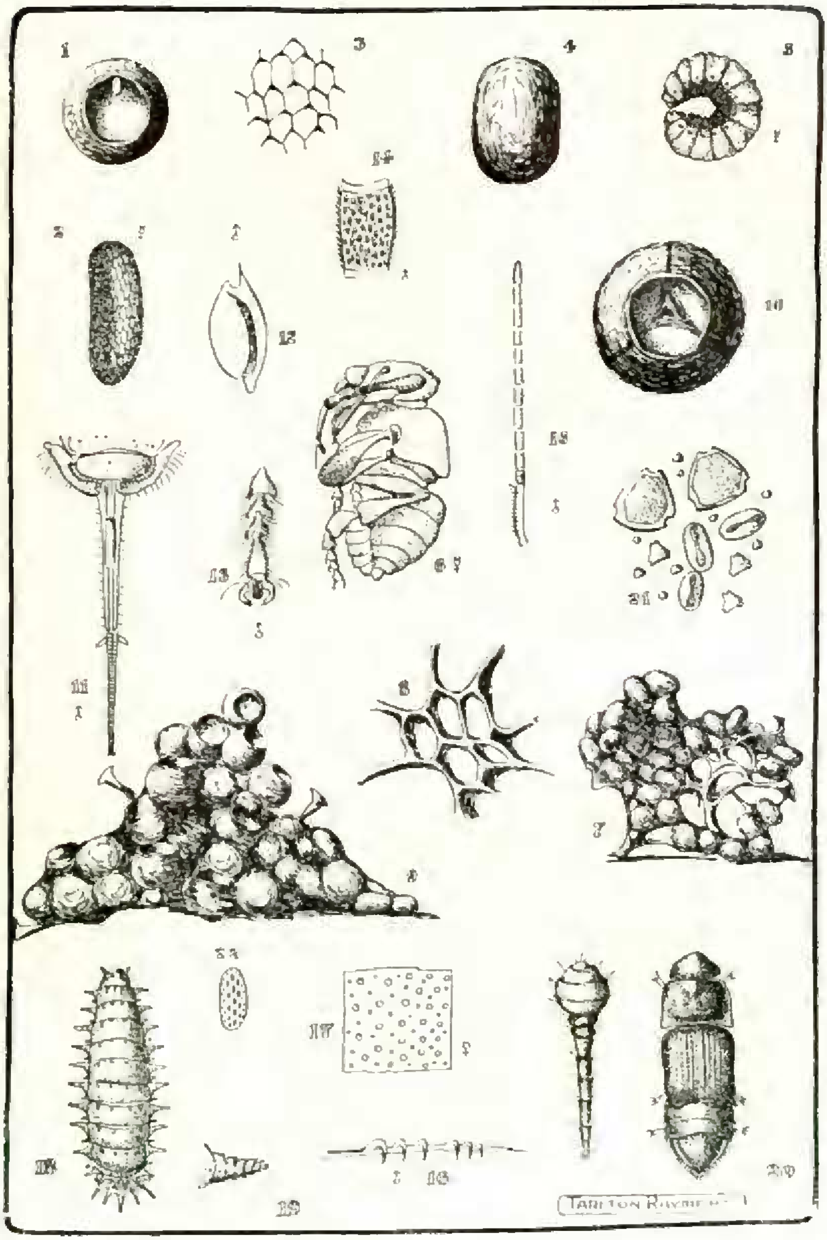

Fig. 3.
Details of *Trigona cassiae* Cockerell.

There is little difference in the size of the worker-cells of these two species, the less compact ones of the latter measure almost 5 mm. in length, those of the former being slightly smaller, but better arranged in horizontal layers. One nest of this species being very symmetrical indeed. I am unable to discern any differences in the drone-cells.

The wax on the worker-cells of *T. cassiae* is exceedingly thin in places owing to its being unevenly distributed, but when the cell is immersed in turpentine, the cocoon is soon cleared of the small amount of wax, and the skin shines with a brilliant golden lustre. Microscopical examination of the cleared skin shows no threads of coarse silk, such as are prominent in the cocoons of *Apis*, but resembles the clear tissue of the cell of *Euryglossa*. The newly-spun silk threads of the hive-bee do not completely fuse together, but the glandular material of *Trigona* and *Euryglossa* most certainly solidifies into a homogeneous membrane capable of holding liquids. The capacity of the worker-cells is about ·06 c. cm.

The white, dry, powdery appearance of the honey-comb of *Apis mellifera* is due to the inclusion of an air-film which separates the wax from the contained honey, but the product of *A. ligustica* often lacks this desirable appearance, since the wax cap lies flat on the honey, giving it a "water-soaked" translucence. This "sodden" surface is found on all the honey-containers of the Australian *Trigona* I have studied.

I append a few notes from various correspondents in South Africa, and which demonstrate clearly a general similarity in habits.

Mr. Lang, Fig-tree Station, Rhodesia, writes:—

"The M'bongolwane is a tiny black bee like a miniature fly. It makes its nest in the 'mopani' ground, usually an ant's nest, and lines the inside with a brown wax. It stores the honey in cells in the bottom of the holes, and the eggs are deposited around the side-walls. The whole swarm could be put into an ordinary match-box. The honey is deep-brown, and tastes sour; a very large hive may contain a cupful." This is probably *T. braunsi* Tohl.

"There is another stingless bee, a large kind that builds in hollow trees. The wax-frame is about six inches in length, with a diameter of fourteen inches. It is sometimes a solid block of capsules, each of which is the size of a thimble. The wax is very dark, and as the capsules are filled the edges are drawn together.

"The honey, though thin and slightly acid, is very refreshing. The bees are larger than the house-fly, and are of a dark reddish-brown, slightly striped. The queen is larger, about the size of a full-grown blue-bottle fly. When the colony is in full work, the flight has the appearance of a twisted rope entering the hole in the tree." The description here given may indicate *T. zebrae* Friese, or *T. denoiti* Vachel.

"There is a third kind of bee, not much larger than a gnat, with a longish black body. The nest is in hollows in trees, and the capsules are about half the size of a pea. I once cut off a small limb containing a colony of these bees, and closed the ends with Boer meal. I then carried it some hundreds of miles in a kit bag, and finally railed it to Grahamstown. The journey occupied six weeks, the young developed, and most of the adult bees were alive when I presented it to the Museum. The native name for these bees is 'Gubenchani'." I have been unable to determine the species referred to in the final paragraph.

A few of the *Karbi* nests had several layers of horizontal brood-combs arranged in such an ordered fashion as to recall the architecture of the paper-wasps of Europe. The general outline was subspherical, and the first or uppermost comb was only 2·5 cm. in diameter; the second 5 cm.; the third 8 cm.; the fourth 10 cm.; and the sixth 5 cm.

The cells of several of these combs were almost true hexagons, and ten of the "worker" pattern equalled in length 2·5 cm. One might say that each superficial inch of "comb-face" contained approximately 100 worker-cells. The distance between the horizontal combs was 5 mm., and the average distance between the struts or toms supporting the layers was 7 mm.; the struts having a height of 2 mm., widened out at their bases and apices to secure a better "bearing surface." This is in accord with the accepted practice of human engineers, and the tendency of supporting columns, of small diameter, to "punch" through the material supported is thus reduced considerably.

One of the above colonies of *T. carbonaria* must have contained about 4,300 worker-cells, some of which looked very dark and hard, as though they had been abandoned for brood-rearing. However, it was a very strong colony, and I have never found any other species of *Trigona* to have such a numerous brood nest. This more or less spherical arrangement of the nursery-combs may not be so uncommon as I imagine, but since they are always surrounded by a maze of honey-cells, and wax struts and supports of all descriptions, only rarely is the naturalist able to bisect the nest without destroying the symmetry of the sphere.

Frequent deviation from a symmetrical arrangement of the combs is also characteristic of the architecture of the hive-bees, and I feel inclined to believe that the defect is due to the character of the walls of the hive; where these are not strictly upright, the honey-bees still build their combs on a vertical plane, and odd-sized pieces of comb are constructed in the angular spaces, care being taken to preserve the essential quarter of an inch space between the comb-faces, and which constitutes the bees' gangway.

It seems, then, that the "bee-way" for *Trigona* is about 5 mm.

EXPLANATION OF FIGURE 3.

1. Looking inside a brood-cell, with an egg on the pollen-batter.
2. The egg of *Trigona* is only slightly bowed.
3. The surface is sculptured with a hexagonal pattern.
4. A sealed brood-cell.
5. Larva when the food has all been consumed and the cell sealed.
6. Worker-pupa three days before emerging from the cell.
7. Cluster of brood-cells showing the loose structure.
8. Portion of the framework, or struts; note the more or less hexagonal pattern.
9. The cluster of honey storage-cells is not so compact as that of *T. carbonaria* Sm.
10. One of the storage-cells, viewed partly by transmitted light, demonstrates the elements of the rhomboidal construction of the honey-bee.
11. Labrum, mandibulae, glossa and palpi of the male *Trigona*.
12. Strigil or antenna-cleaner of the male.
13. Tarsal segments and claws of the male's foot.
14. A segment of the male flagellum showing the pore and peg organs.
15. Antenna of the male.
16. Hamuli or wing-hooklets of the male.
17. Tegument of a pupa almost fully developed, shewing the puncturation.
18. Many thousands of these spiny larvae were removed daily by the bees.
19. One of the appendages under higher magnification.
20. Many of these beetles, *Brachypeplus planus*, Er., were found in the colonies.
21. *Eucalyptus* and other pollen-grains found in the larval food.
22. One of the thousands of white eggs attached to the walls of the hive by a fly.

In the course of a report on his recent visit to the Union of South Africa, Sir Arthur Hill, Director of the Royal Botanic Gardens at Kew, England, makes the following observations:—"I cannot help referring to the possible disappearance of rare and remarkable plants through the activities of "collectors" of "Wild Flowers" for flower shows, and to the lavish use of unique native plants for the decoration of motor cars, etc., at such functions; a practice which is causing alarm to botanists and plant lovers in South Africa, Great Britain and throughout the botanical world."

The Insect Menace, by Dr. L. O. Howard, is an outstanding work, both popular and scientific, recently published in the United States. The author is one of the foremost entomologists of the world and writes with the authority of great knowledge, yet in a very readable style. A copy of his latest book has been purchased for the Club library. Other books will be added, a sum of £5 being available for such purchases from the Special Best Fund.